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**The Sixth International Conference on  
Industrial Engineering and Operations Management  
Kuala Lumpur, Malaysia, March 8-10, 2016**

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The members of the Organizing and Program Committee would like to thank you for attending and participating in the 6th International Conference on Industrial Engineering and Operations Management (IEOM) – Kuala Lumpur 2016. The conference offers a diverse and vigorous scientific program, encompassing many traditional topics as well as new and emerging scientific themes.

We would like to acknowledge the efforts of the many authors and reviewers that contributed to nearly 500 research papers and abstracts included in this year's technical program. These papers comprise the conference proceedings for 2016 and will be available online following the conference via [www.ieomsociety.org/](http://www.ieomsociety.org/).


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# **Performance Measurement in PT. XYZ Using The Balanced Scorecard (a case study of PT. XYZ)**

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**Abstract**— PT. XYZ is company that produce some plastic house ware. It has a problem in measuring the company's performance. Even though, there are a lot of factors that influence the company's performance, but this company still only used financial factors to measure their performance. This paper discuss about performance measurement using. Balanced Scorecard always looks a business from four perspectives. Those perspectives are financial, customer, internal business process, and learning and growth. The result of the Balaced Scorecard application in PT XYZ is 12 KPIs (Key Performance Indicators). Performance measurement is conducted for 8 periods. The performance measurement result showed that the company have good performance during 8 periods but there were 2 KPIs often below the target limits and 5 suggestions are proposed to improve the company's performance.

**Keywords**—*Performance measurement, Balanced Scorecard*

## **I. INTRODUCTION**

Every company should give their best performance in order to win the competition. Nowadays, there are lots of plastic industries. To build the competitive advantage, they must start from developing their business strategies. After developing strategies, they must be able to measure and control their performance. Many companies usually measure their performances in the short, medium, and long term. There are many ways to conduct performance measurement. Each performance measurement method has its own characteristics. So, the biggest challenge is to choose the best method that suitable with the company condition.

PT. XYZ conducted the measurement of performance based on the financial aspect. PT. XYZ has not considered the other aspects that may affect to the company. The company's performance was said low when the profit did not reach the target and vice versa. However, this performance measurement method can become a big problem for the company. The company can be easily beatten by the competitors because the company never pay attention to the other aspects as customer satisfaction, company growth, etc.

Due to this condition, the company should develop their method to measure the performance. Balanced Scorecard (BSC) is one of the the applicable methods in measuring company performance. BSC does not only look the financial aspect, but also consider the nonfinancial aspects. The Balanced Scorecard method was introduced by Robert s. Kaplan and David P. Norton in the 1992. This method can translate company's vision, mission, and strategy into four perspectives. Those are financial, customer, internal business process, and learning and growth perspectives.

When the four perspective is set in, all of the levels in the company can be focused to reach the goal. BSC will be used in measuring PT. XYZ performance. Further, the results will be analyzed. This method is expected to help the company figure out their performance.

## **II. LITERATURE REVIEW**

### *Balance Scorecard in Small Medium Enterprise*

Balance scorecard was developed by Kaplan and Norton in 1992. At first, balanced scorecard was developed for large companies. Many studies had been done to apply Balance Sorecard in large companies. We noticed that Balanced Scorecard had successfully resolved some strategic issues in the large company, such as how to integrate financial information with non-financial information and calculate incentive for the employee (Kaplan, 2010).By applying balanced scorecard, every employee in the organization is charged to focus on important business drivers (Isoraite, 2008).

Nowadays, we realize not only large companies have strategic issues, but also small and medium sized enterprises (SMEs). We had seen many SMEs faced the challenge to survive through the crisis. SMEs are more vulnerable to external shocks because their size and limited resources, in particular limited financial, managerial and information resources (Skorvagova et al., 2014). Nevertheless, SMEs play a pivotal role in sustainable development through generation of employment, increasing export and industrial production, social uplifting and political stability in developing economies (Nyanga et al., 2013). Balanced scorecard is expected to assist them in managing strategy for any changes in the external environment. Thus, SMEs can be more agile to face the challenge.

Some researchers had identified the unique characteristics of SME. Garenco et al. (2005) told us that SMEs are fundamentally different in three aspects: uncertainty, innovation, and evolution. Kureshi et al. (2009) noted that there are three distinctive attributes of SMEs. They are including number of employees, paid-up capital, and annual revenues. Furthermore, SMEs are usually conducted and managed by their owners. Their relative small size and favourable working environment facilitate the cooperation between owner and employees that may often lead to mutual agreement on further development of the company (Skorvagova et al., 2014). Considering that every SME has unique characteristics, so the performance measurement system in SMEs is supposed to use different approach. Seen from the different nature between large companies and SMEs, Andersen et al (2001) concluded that large organization often gain more benefit from the effective communication of their strategy, while the SME gains more from the description of strategic objectives with priorities and the drive for a more effective strategic management process.

Kaplan and Norton (2001) had identified two sources of the failure of the Balanced Scorecard implementation in large companies: the design and the process. Poor design is often caused by

- Too few measures in each perspective, so there is no balance between leading and lagging indicators or financial and non-financial indicators.
- Too many indicators are assigned without considering the critical things
- The KPIs are not aligned with the company's vision, mission, and strategy.

Process failures usually caused by

- Lack of senior management commitment
- Too few individuals involved
- Keeping the scorecard at the top
- Overly long development process
- Treating the Balanced Scorecard as a one-time measurement project
- Treating the Balanced Scorecard as a systems project
- Hiring inexperienced consultants
- Introducing the Balanced Scorecard only for compensation.

The essential factor behind these failures is lack of communication within an organization. While the company was developing performance measurement system, everyone in the organization should be involved so the rejection can be minimized. Nomphe (2011) found that the major cause for the performance measurement failure in SMEs was the company's often changed the strategy. Since beginning to use the Balanced Scorecard, a number of measures were added or revised.

### III. RESEARCH METHODOLOGY

The research methodology is shown below :

#### *A. Preliminary Observations*

The first step in this research was a Preliminary Observation. This stage was used to identify the issues that happen in the company. Interview and discussion with the owners and employees of the company were used to explore the real problem and to gather the data. The results of discussion and interview were mostly about the company condition.

#### *B. Data Collection*

The required data were collected during the interview process with the owners and employees of the company. Besides, the data were also from the company's files. The data collected are in the two types:

##### 1. Primary Data

Primary data is that data collected through interviews and direct observation in the company linked to the vision and mission, organizational structure, and the factors considered in the weighting.

##### 2. Secondary Data

Secondary data is data that is not obtained directly in an interview with company owner is data obtained from the historical files of the company.

### C. Data Processing

After collecting the necessary data, then the data were processed. The steps of data processing is conducted as follows:

1. Describe the vision and mission of the company.
2. Determine the strategies needed by the company.
3. Determine the long-term goals and short-term based strategy which has been obtained previously.
4. Determine KPI (Key Performance Indicator) for each strategy/ objective
5. Perform weighted KPIs and four perspective.
6. Design the Scorecard

### D. Conclusions and suggestion

The last stage is conducted by making conclusions based on the results of data processing and data analysis. The researcher also give some improvement suggestions which are expected to be useful for the company's progress.

## IV. RESULT AND DISCUSSION

### A. Vision, Mission and Strategy

Vision can be defined as goals to be achieved by the company. By knowing the vision of the company, all employees will be able to determine the best action or step that they need to do to achieve the company's vision.

Mission is the guidance of what is to be done by the organization (Single, 2002). Mission can be described as a set of tasks that must be carried out by the organization or company in order to achieve their vision. The mission statement can be reference in formulating the company strategies. Vision, mission, strategies and the Key Performance Indicator (KPI) for each strategy can be seen on Figure 1.

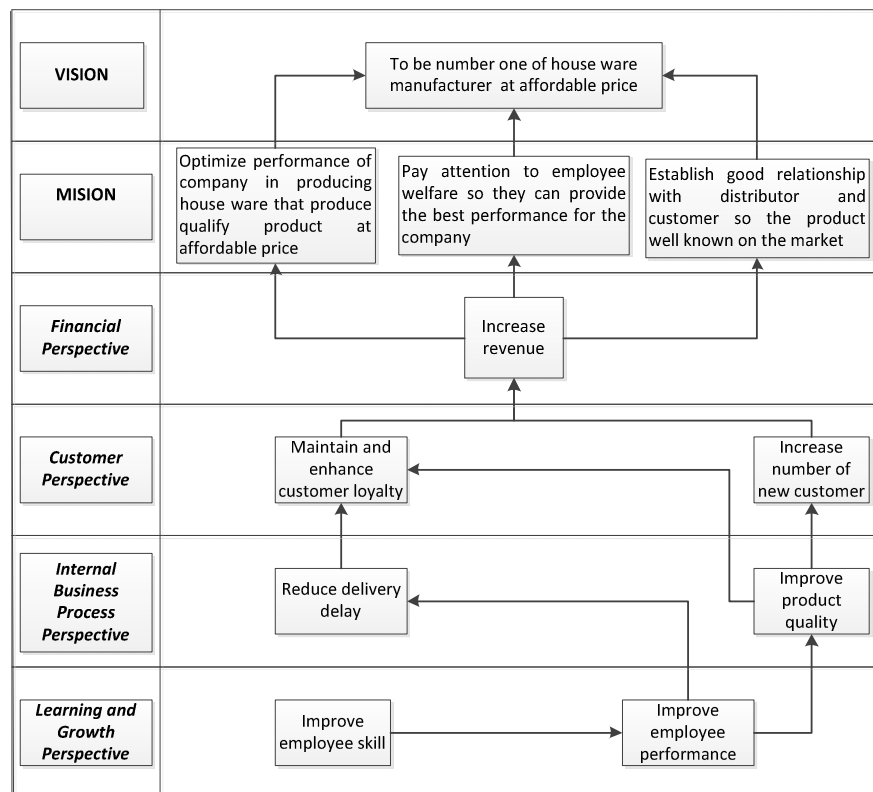


Fig. 1. Strategy Map



### B. Key Performance Indicator

After determining the strategy, the next step is generating the KPI's of each strategy. These KPI's are clasified into four perspective of BSC.

TABLE 1. RELATIONSHIP BETWEEN THE STRATEGY AND KPI'S

Perspective	Strategy	KPI
Financial	Increase revenue	Sales Growth (SG)
		Gross Profit Margin (GPM)
		Net Income Growth (NIG)
Customer	Increase number of customer	% new customer (PoNC)
	Maintain and enhance customer loyalty	Customer retention (CRt)
		Number of complaint (NC)
		Product return (PR)
Internal Business Process	Reduce delivery delay	% of on time delivey (PoTD)
	Improve product quality	% of defect (PoD)
Learning and Growth	Improve employee skill	Employee turnover (ETO)
		Absenteeism (Ab)
	Improve employee performance	Employee productivity (EP)

### C. Weight of each criteria

Simple Multi-Attribute Rating Technique (SMART) Weighting Method is very useful to solve the decision making problem with multiple criteria. By using the SMART method, a decision maker will get ease in the weighting process. Even though, the weighting process can be finished easily through a single assessment but it still has a high degree of accuracy. SMART is applied to consider the weights for each perspective in balanced scorecard with its KPI's. The weight of perspective and KPI are display on Table 2.

TABLE 2. WEIGHTING OF PERSEPCTIVE AND KPI'S

Perspective	Weight of Persepctive (%)	KPI	Weight of KPI (%)	Final Weight of KPI (%)
Financial	33,62	SG	46,46	13,9
		GPM	12,12	4,1
		NIG	41,41	15,6
Customer	23,98	PoNC	19,44	4,7
		CRt	29,68	7,1
		NC	27,35	6,6
		PR	23,53	5,6
Internal Business Process	28,80	PoTD	50,40	14,5
		PoD	49,60	14,3
Learning & Growth	13,60	ET	30,09	4,1
		Ab	26,62	3,6
		EP	43,29	5,9

### D. Company's Performance

The assesment of performance measurement can be seen in Table 3.

TABLE 3. ASSESSMENT RESULTS FOR EACH KPI FOR 8 PERIODS

Perspective	Weight of Persepctive (%)	KPI	Weight of KPI (%)	Final Weight of KPI (%)	Score								Average Score
					P1	P2	P3	P4	P5	P6	P7	P8	
Financial	33,62	SG	46,46	15,60	1	2	4	4	1	2	3	4	2.63
		GPM	12,12	4,10	4	3	3	2	4	4	4	3	3.38
		NIG	41,41	13,90	1	1	2	3	1	3	3	5	2.38
Customer	23,98	PoNC	19,44	4,70	3	2	3	1	3	3	4	2	2.63
		CRt	29,68	7,10	4	4	4	4	3	3	4	2	3.50
		BK	27,35	6,60	3	4	2	4	3	3	4	4	3.38
		PR	23,53	5,60	4	3	2	4	4	3	4	4	3.50
Internal Business Process	28,80	POTD	50,40	14,50	4	4	4	4	4	4	4	4	4.00
		PoD	49,60	14,30	4	4	4	4	4	4	4	4	4.00
Learning and Growth	13,60	ET	30,09	4,10	5	5	5	4	5	4	5	4	4.63
		JA	26,62	3,60	4	4	4	4	4	4	4	4	4.00
		EP	43,29	5,90	5	5	5	5	5	5	5	5	5.00

The following Table 4. and Figure 2. are the performance results on each perspective

TABLE 4. PERFORMANCE RESULTS THAT PT XYZ EVERY PERSPECTIVE FOR 8 PERIODS

Perspective	Weight of Perspective (%)	Weighted Score							
		P1	P2	P3	P4	P5	P6	P7	P8
Financial	33,62	1,36	1,71	3,05	3,34	1,36	2,66	3,12	4,29
Customer	23,98	4,42	3,23	2,72	3,27	3,13	2,89	3,86	3,47
Internal Business Process	28,80	4,00	4,00	4,00	4,00	4,00	4,00	4,00	4,00
Learning and Growth	13,60	4,73	4,73	4,73	4,43	4,73	4,43	4,73	4,43

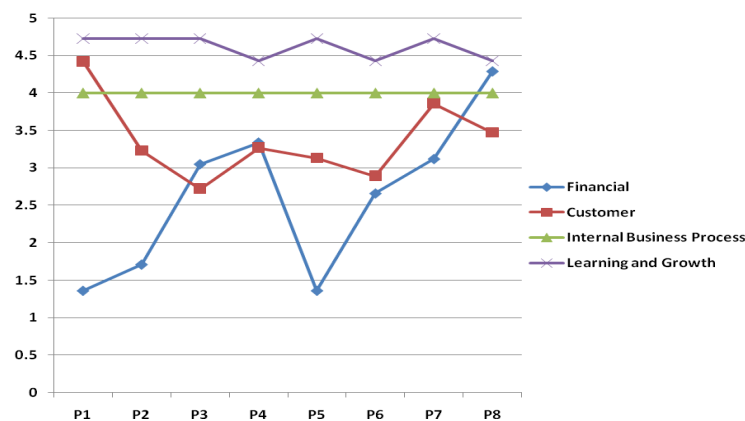


Figure 2. Perspective's Performance

Figure 2. shows that performance of financial perspective is lowest than others. Its mean that performance of financial perspective should be improved. The financial perspective consist of three KPI's i.e. Sales Growth (SG), Gross Profit Margin (GPM) and Net Income Growth (NIG). Performance of SG and NIG are low so these KPI's should be improved. Table 5. is the suggestion to improve the performance.

TABLE 5. IMPROVEMENT SUGGESTION

Problematic KPI	Common Causes	Special Causes	Improvement Suggestion
Sales growth	Less promotion	Rely on more than one customer	Maintain the quality of the product is already good and improved customer
		Lack of marketing	Increase sales forces especially outside of Java Island
	Unstable sales	Increase business competition	Maintain product quality
		Customer assumption that price will increase at the beginning of year	Provide precise information about product price
Net income growth	High cost	High cost of machine maintenance	Add machine as well as maintenance schedule optimization
		Number of labor	Employee scheduling
	Low price	Increase business competition	Maintain product and service quality

## V. CONCLUSION

Conclusion of this reasearch are

1. The best performance of the company is learning and growth perspective and the worst performance is finance perspective.
2. There are still rooms for improments especially for the KPIs that have not met with the target yet. Sales Growth (SG) and Net Income Growth (NIG) may have better performance if the KPIs' score small but have a large global weight.

3. To find out the root causes of the below-target KPIs, it was used Ishikawa Diagram. Improvement suggestions will be made after all of the causes were identified.
4. Dashboard performance is done to simplify the data presentation. Only KPIs with big weight that will be shown in the dashboard.

#### REFERENCES

- [1] Kaplan, Robert S, " Conceptual Foundations of the Balanced Scorecard1", Working Paper, Harvard Business School, Harvard University, 2010.
- [2] İşoraitè, M." The Balanced Scorecard Method: From Theory To Practice" *Intelektinė Ekonomika Intellectual Economics* 2008, No. 1(3), P. 18–28
- [3] Skorvagova, S, Pasztorova, J., "The Global Crisis And Small- And Medium-Sized Enterprises: Threat Or Challenge?", *European Scientific Journal /Special/ Edition Vol.1 Issn: 1857 – 7881 (Print) E - Issn 1857- 7431*, February 2014
- [4] Nyanga, T., Zirima, H., Mupani, H., Chifamba, E. and Mashavira, N." Survival Of The Vulnerable: Strategies Employed By Small To Medium Enterprises In Zimbabwe To Survive An Economic Crisis" *Journal of Sustainable Development in Africa*, Volume 15, No.6, 2013
- [5] Garengo, P., Biazzo, S., & Bititci, U. S. "Performance Measurement Systems in SMEs: a Review for a Research Agenda" *International Journal of Management Reviews*, (7)1, 25-47.<http://dx.doi.org/10.1111/j.1468-2370.2005.00105.x>, 2005.
- [6] Kureshi, N. I., Mann, R., Khan, M. R., & Qureshi, M. F. "Quality management practices of SME indeveloping countries: a survey of manufacturing SME in Pakistan. *Journal of Quality and Technology Management*, 5(11): 63-89, 2009
- [7] Andersen, H. "Balanced Scorecard Implementation in SMEs: Reflection on Literature and Practice", 4<sup>th</sup> SME-SME International Conference, Allborg University, Denmark, 14-16 May
- [8] Kaplan, R. S., and Norton, D. P., "Transforming the balancedscorecard from performance measurement to strategic management: part I". *Accounting Horizons* 15(1):87–104, 2001
- [9] Rompho, N,"Why the Balanced Scorecard Fails in SMEs: A Case Study" *International Journal of Business and Management* Vol. 6, No. 11, 2011, p. 39-46

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